

Factors affecting the incidence of hypertension

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The incidence of hypertension was determined among 10 173 patients of general practices in southwestern Ontario studied from 1978 to 1982. For both sexes the incidence of hypertension rose with increasing age. The incidence was higher among men than among women until age 50, after which it was similar for the two sexes. Obesity was positively associated with incidence for both sexes. In men this association diminished significantly with increasing age. The similar trend in women fell just short of statistical significance. In men but not women heavy alcohol consumption was positively related to the incidence of hypertension. However, the broad definition of this variable may have obscured a relation in women. Among men the effect of obesity on the incidence of hypertension was less for heavy drinkers than for light drinkers. Smoking was not related to the incidence of hypertension in either sex.

De 1978 à 1982 on a établi la fréquence de survenue de l'hypertension artérielle parmi 10 173 personnes faisant partis de plusieurs clientèles de médecine générale dans le sud-ouest de l'Ontario. Pour les deux sexes elle augmente avec l'âge. Elle est plus grande chez les hommes que chez les femmes jusqu'à 50 ans mais semblable passé cet âge. Pour les deux sexes également, elle est en rapport positif avec l'obésité. Chez les hommes ce rapport s'atténue de façon significative à mesure que l'âge augmente; la même tendance, observée chez les femmes, demeure juste en deçà de la signifi-

cation statistique. C'est seulement chez les hommes que l'hypertension est en rapport avec la forte prise d'alcool; la définition assez large que nous avons adoptée de celle-ci a pu brouiller un rapport semblable chez les femmes. L'obésité des hommes a moins d'effet sur la fréquence de l'hypertension chez les forts buveurs que chez les légers. On ne trouve aucun rapport de cette fréquence avec l'usage du tabac dans l'un et l'autre sexe.

Several studies of the incidence of hypertension have examined factors affecting the development of elevated blood pressure. André and colleagues¹ examined the effects of age, obesity, heart rate and plasma levels of glucose, cholesterol and urate on the 5-year incidence of hypertension among 11 355 adults in a city in France. Their sample was self-selected since the subjects were from households that responded to an invitation to visit a family health centre for a physical examination. Obesity in both sexes and the plasma urate level in women were the variables most closely associated with the incidence of hypertension. Apostolides and associates² reported age-adjusted 3-year incidence rates for subjects in the Hypertension Detection and Follow-up Program in the United States, according to sex, race and initial blood pressure. Blacks of both sexes had higher rates than whites. Black and white people of both sexes with initially labile blood pressure had higher rates than people with initially stable normotension.

Incidence rates over a 12-year period from the Framingham study were reported by Kannel and coworkers.³ After adjustment for sex and age, they found that initial obesity and weight gain during the follow-up period were associated with a higher incidence of hypertension. Robitaille and collaborators,⁴ who followed 4828 Quebec men aged 35 to 64 years over 6 years, found that the incidence of

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hypertension was higher in men who were obese. An incidence study among men employed at the Peoples Gas and the Western Electric companies in Chicago revealed elevated rates of hypertension among "problem drinkers" and among men who consumed six or more drinks per day.⁵

This report supplements the results of previous studies by presenting incidence data for men and women by age, obesity status, alcohol consumption and smoking habits.

Methods

In a randomized controlled trial of the value of screening for hypertension in 34 general practices in southwestern Ontario, all patients aged 20 to 65 years in the 17 experimental practices were screened for hypertension during office visits from 1978 to 1982.⁶ The patient population was predominantly white, and the age and sex distributions closely resembled those of the census population in southwestern Ontario.

Patients who were normotensive and not taking antihypertensive drugs at the beginning of the study and who subsequently had a diastolic pressure of 90 mm Hg or greater on at least two consecutive office visits were considered to represent incident cases. Among initially normotensive patients the average number of office visits per year was 2.8, and 78% had their blood pressure measured in 2 or more of the 5 years of the study.

Obesity was defined as a body mass index (weight in kilograms divided by height in square metres) greater than 27 for men and greater than 25 for women. Current alcohol consumption and smoking habits were determined from responses to a questionnaire given to all the subjects.

Subjects who moved or died or for whom

information was missing on weight, height, alcohol consumption or smoking habits were excluded from the analysis.

Since there was a strong possibility of confounding among the independent variables, multivariate analysis was carried out, separately for men and women. Logistic regression analysis was performed; initially all pairwise interactions were included in the model, but only interactions that were statistically significant for either sex were retained in the final model. Alcohol consumption was treated as a three-category construct represented by two dummy variables, with light drinking (less than one but more than zero drinks per day) as the reference category.

Results

In the 17 experimental practices there were 14 099 initially normotensive subjects; 1131 were lost to follow-up, and for 2795 information was missing on at least one of the independent variables. Thus, 10 173 subjects, 5614 women and 4559 men, remained for analysis.

The incidence of hypertension rose with increasing age for both sexes and was higher among men than women until age 50, after which the rates were similar for the two sexes (Table I).

The effect of obesity on the incidence of hypertension varied according to age (Table II). A higher incidence was observed among obese than among nonobese subjects, but the difference diminished steadily with increasing age.

The effect of alcohol consumption is shown in Table III. For both sexes the incidence was higher among nondrinkers than among subjects who reported an average consumption of less than one drink per day. The incidence rose with consumption beyond one drink per day more steeply among men than among women.

Smoking had little effect on the incidence of hypertension: the rates among smokers and non-smokers were 7.3% and 8.1% respectively.

The results of multiple logistic regression analysis are shown in Table IV. Age, obesity and heavy drinking were significantly associated with the incidence of hypertension among men. A diminishing effect of obesity on incidence with increasing age was reflected in the significant negative interaction between age and obesity. The negative interaction between obesity and heavy drinking

Table I — Incidence rates of hypertension, by age and sex, among 10 173 subjects in southwestern Ontario studied from 1978 to 1982

Age at entry, yr	Rate, % (and no. of subjects)	
	Men	Women
20-29	3.4 (1334)	2.3 (1943)
30-39	7.9 (1235)	4.5 (1480)
40-49	12.9 (913)	10.4 (1017)
50-59	16.9 (793)	16.2 (888)
60-65	20.4 (284)	21.3 (286)

Table II — Incidence rates of hypertension, by age and obesity status

Age at entry, yr	Rate, % (and no. of subjects)		Relative risk for obese subjects
	Obese	Nonobese	
20-29	5.7 (706)	2.0 (2571)	2.8
30-39	10.8 (812)	4.0 (1903)	2.7
40-49	18.6 (641)	8.1 (1289)	2.3
50-59	22.1 (551)	13.8 (1130)	1.6
60-65	23.2 (185)	19.7 (385)	1.2

was also significant, which indicated that the effect of obesity on incidence was less among heavy drinkers.

For women age and obesity were significantly associated with incidence. The interaction between age and obesity was in the same direction as for men but fell just short of statistical significance.

The *p* values for goodness of fit in both regression analyses exceeded 0.25 (0.65 for men and 0.29 for women), which indicated that the regression models provided a reasonable fit to the data.

Discussion

Before we discuss the interpretation of our results, some consideration of methodologic issues is necessary. First, we must emphasize that the reported incidence rates cannot be generalized to the population of southwestern Ontario, because they do not come from a random sample of the population of the area.

Second, there is the question of the accuracy of the blood pressure measurements by the participating physicians. Since it was not feasible to

monitor the physicians' performance, errors of measurement would have been greater than in blood pressure surveys in which standardized techniques are used. With one exception, the errors are unlikely to be related to the independent variables. The exception is obesity: using too small a cuff in an obese patient can give a spuriously high blood pressure reading. Although the participating physicians were supplied with large cuffs, we cannot be certain that they were always used for measuring the blood pressure of obese subjects. If this error is responsible for the observed higher incidence of hypertension among obese subjects, it is surprising that the relation between obesity and incidence declined with increasing age, unless greater care with cuff size was taken for older subjects.

Third, there is the possibility of selection bias. Of the 14 099 initially normotensive subjects 28% were excluded, 8% because they were lost to follow-up and 20% because information was not available for all the independent variables. In the interest of brevity we have shown results of the univariate analyses only for the sample corresponding to that used in the regression analysis. We carried out other univariate analyses using the maximum sample size available for each independent variable. In each instance the pattern of incidence was the same as in the smaller sample.

Fourth, the opportunity for a diagnosis of hypertension may have been confounded with one or more of the independent variables, because the frequency of blood pressure measurement depended to some extent on the frequency of a patient's visits to the physician. An examination of the independent variables in relation to frequency of blood pressure measurement showed no systemat-

Table III — Incidence rates of hypertension, by alcohol consumption and sex

Average no. of drinks per day	Rate, % (and no. of subjects)	
	Men	Women
0	11.3 (512)	10.3 (1048)
< 1	7.8 (2393)	6.8 (3954)
1-3	12.2 (1449)	7.4 (580)
≥ 4	15.6 (205)	9.4 (32)

Table IV — Multiple logistic regression analysis of the effects of age, obesity, alcohol consumption and smoking on the incidence of hypertension

Variable	Coefficient	Coefficient ÷ standard error	Adjusted relative odds ratio (and 95% confidence limits)
Men			
Age	0.060	10.93*	1.06 (1.05, 1.07)
Obesity	1.039	5.09*	7.99 (3.59, 17.80)
Heavy drinking	0.349	4.83*	2.01 (1.51, 2.67)
Nondrinking	0.043	0.38	1.09 (0.70, 1.70)
Smoking	-0.094	-1.81	0.83 (0.68, 1.02)
Age v. obesity	-0.027	-3.09†	0.97 (0.96, 0.99)
Obesity v. heavy drinking	-0.224	-2.02‡	0.64 (0.41, 0.99)
Obesity v. nondrinking	0.097	0.59	1.21 (0.64, 2.31)
Women			
Age	0.072	12.03*	1.08 (1.06, 1.09)
Obesity	0.803	3.90*	4.99 (2.22, 11.20)
Heavy drinking	-0.124	-1.06	0.78 (0.49, 1.23)
Nondrinking	0.033	0.37	1.07 (0.75, 1.52)
Smoking	0.058	1.05	1.12 (0.90, 1.39)
Age v. obesity	-0.016	-1.85	0.98 (0.97, 1.00)
Obesity v. heavy drinking	0.097	0.56	1.21 (0.61, 2.40)
Obesity v. nondrinking	-0.019	-0.15	0.96 (0.59, 1.58)

**p* ≤ 0.001.

†*p* ≤ 0.01

‡*p* ≤ 0.05.

ic associations. However, frequency could be measured only at the crude level of the number of years in which blood pressure was recorded at least once. Therefore, we cannot entirely eliminate this possibility.

For both sexes the association between obesity and the incidence of hypertension declined with increasing age (although the interaction between obesity and age failed to reach statistical significance in women). This phenomenon has also been observed in studies of the prevalence of hypertension.⁷ Two interpretations can be suggested. The first assumes that the elderly obese subjects were obese earlier in life and that they represent a select subgroup with greater resistance to the cardiovascular consequences of obesity. The second interpretation is that the elderly obese subjects had a late-onset form of obesity that is less likely to cause hypertension. It is difficult to favour one interpretation over the other, given the cross-sectional nature of our data on obesity.

Among men the incidence of hypertension was significantly higher in heavy drinkers than in light drinkers. This observation is in agreement with the results of a randomized cross-over experiment reported by Puddy and colleagues,⁸ in which a reduction in alcohol intake was followed by a significant fall in systolic blood pressure, independent of weight loss. No relation between alcohol consumption and incidence of hypertension was found among women after adjustment for age and obesity. Since heavy drinking was defined as more than one drink per day, the absence of an association may reflect the fact that most of the women consumed just over one drink per day, whereas most of the men in this category consumed considerably more than one drink per day. A finer categorization of alcohol consumption is needed before one can conclude that alcohol consumption has less of an effect on the development of hypertension among women than among men.

The interaction between the effects of obesity and heavy drinking on the incidence of hypertension in men has not to our knowledge been reported before. This may be a chance finding. If not, by what mechanism might obesity have a lesser effect on the development of hypertension among men who consume more than moderate amounts of alcohol? We must leave this as a rhetorical question. Clearly it warrants further

investigation. Psychologic and environmental factors that may be confounded with alcohol consumption and with obesity should be taken into account in future studies. As Ashley⁹ pointed out, the use of alcohol is a behaviour that has complex determinants.

Our failure to detect an effect of smoking on the incidence of hypertension cannot be taken as evidence in favour of smoking. Its relation with coronary artery disease, irrespective of hypertension, and its association with other diseases warrant the promotion of smoking cessation.

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Two grand principles

Remember, my friend, that bleeding and drinking warm water are the two grand principles; the true secret of curing all the distempers incident to humanity.

— Alain René Lesage (1668-1747)